GROUP 54C

CONTROLLER AREA NETWORK (CAN)

CONTENTS

GENERAL INFORMATION

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CAN, an abbreviation for Controller Area Network, is an ISO-certified international standard for a serial multiplex communication protocol[*1]. A communication circuit employing the CAN protocol connects each ECU, and sensor data can be shared among, which enables more reduction in wiring.

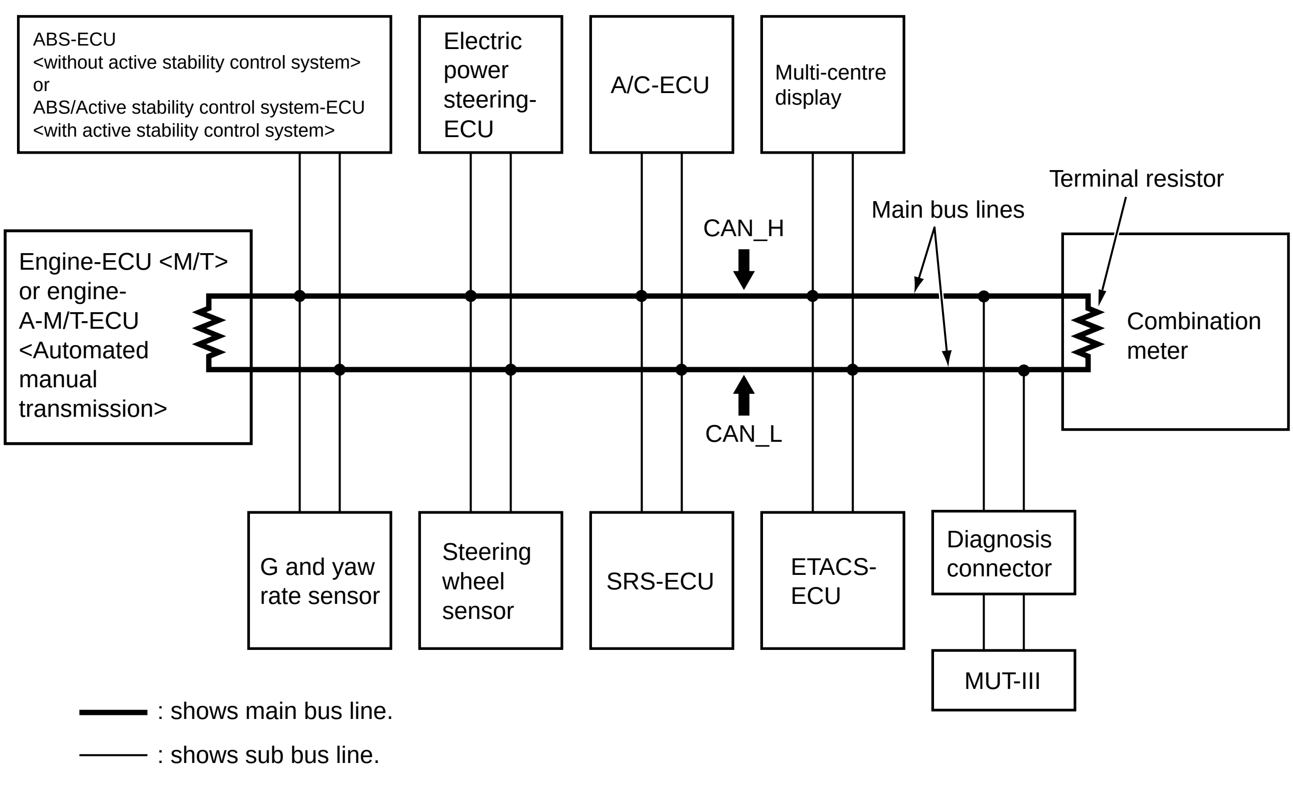
*NOTE: [*1]: The regulations have been decided in detail, from software matters such as the necessary transmission rate for communication, the system, data format, and communication timing control method to hardware matters such as the harness type and length and the resistance values.*

CAN offers the following advantages.

- Transmission rates are much faster than those in conventional communication (up to 1 Mbps), allowing much more data to be sent.
- It is exceptionally immune to noise, and the data obtained from each error detection device is more reliable.
- Each ECU connected via the CAN communicates independently, therefore if the ECU enters damaged mode, communications can be continued in some cases.

STRUCTURE

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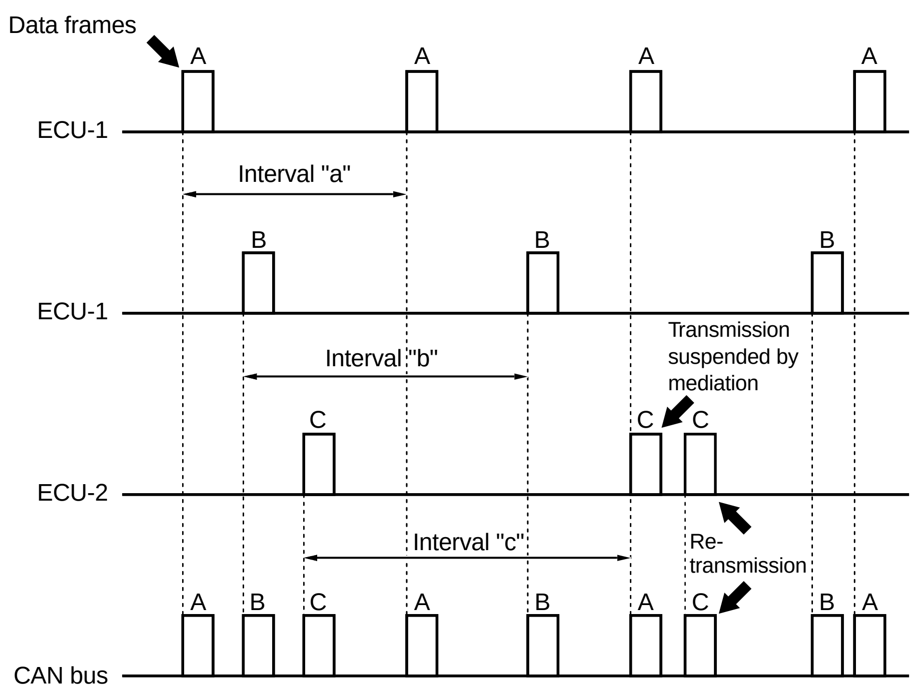
- The CAN bus line consists of two lines, CAN_L and CAN_H (CAN Low and CAN High, respectively), as well as two terminal resistors (A twisted-pair cable, highly resistant to noise, is used for the communications line).
- The CAN bus line connecting the two terminal resistors is the main bus line, and the CAN bus line connecting each ECU is the sub-bus line.
- The terminal resistors are installed in the engine-ECU <M/T> or the engine-A-M/T-ECU <Automated manual transmission> module and connection meter to stabilize communication signals (The terminal resistance is set at approximately 120 Ω).
- A maximum of 10 ECUs are connected in the COLT CAN bus line as follows.
  - Engine-ECU <M/T>

- Engine-A-M/T-ECU* <Automated manual transmission>
- ABS-ECU <Vehicles without active stability control system>
- ABS/Active stability control system-ECU <Vehicles with active stability control system>
- Steering wheel sensor <Vehicles with active stability control system>
- G and yaw rate sensor <Vehicles with active stability control system>
- Electric power steering-ECU
- SRS-ECU
- A/C-ECU
- ETACS-ECU
- Multi-centre display
- Combination meter

NOTE: Engine-A-M/T-ECU: Engine automated manual transmission electronic control unit*

OPERATION

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The CAN communication system is described below.

- Each ECU communicating with CAN periodically sends several sensors' information on CAN bus as data frame (called periodical sending data). For further details, consult the data frame section.
- ECUs requiring data on CAN bus can receive data frames sent from each ECU simultaneously.
- The data sent from each ECU conducting CAN communication is transmitted at 10-1000msec interval depending on necessity of data.

NOTE: In the figure above, the data frame A is transmitted in "a" intervals, while the data frames B and C are transmitted at intervals "b" and "c," respectively.

- A single ECU transmits multiple data frames.
- When data frames conflict with one another (when plural ECUs transmit signals simultaneously), data is prioritised for transmission by mediation, therefore, plural data frames are not sent simultaneously. For further details, consult the mediation section.
- Data is transmitted not by the conventional voltage-using method but by voltage potential difference. For further details, consult the section on CAN bus voltage transformation .
- Reliability of each ECU transmitting signals via CAN communication is secured by several error detection and recovery processes. For further details, consult the sections on error detection and system recovery.
- For major communication signals (transmitting signals) among ECUs, refer to P.54C-6.

MEDIATION

Because each ECU transmits data independently on the CAN bus, there are cases of data collision when multiple data frames that ECUs attempt to transmit simultaneously (if multiple ECUs transmit at nearly the same moment). At this moment, processing of the ECUs attempting transmission is performed in the following way.

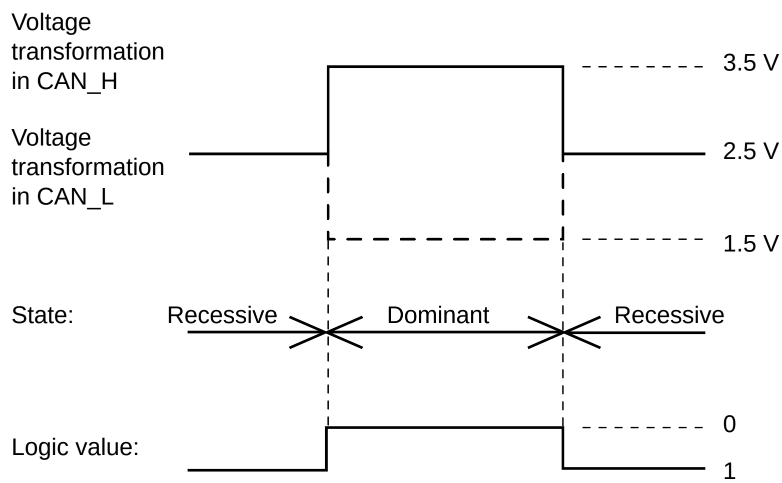
1. Data frame with high priority is transmitted first according to ID codes memorized in data frames.
2. Transmission of low-priority data (data frames) is suspended by the issuing ECUs until the bus clears (when no transmission data exists on the CAN bus).

NOTE: If the suspended state continues for a specific time, new data (data frame content) is created and sent.

3. ECU containing suspended data frames transmits the data when the bus becomes available.

NOTE: There is enough capacity on the CAN bus, which never prevents data frames from being sent.

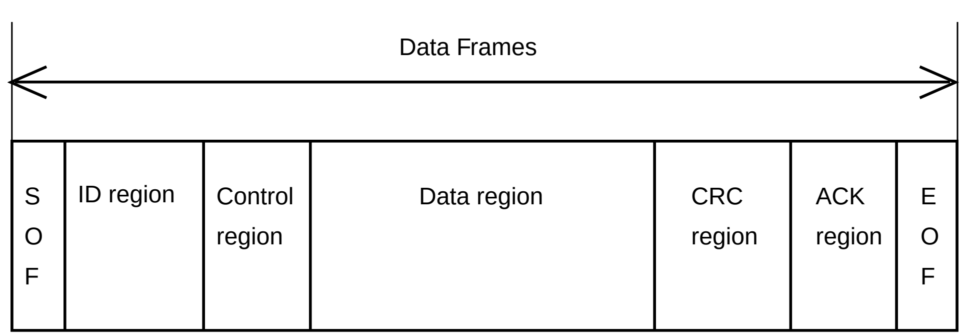
VOLTAGE TRANSFORMATION ON THE CAN BUS



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Data frame transmission through the CAN bus line involves voltage transformation (for output signals) in the distinctive CAN profile as follows. The ECU transmitting through the CAN_H and CAN_L bus lines sends 2.5-3.5V signals to the CAN_H side and 2.5-1.5V signals to the CAN_L side. The receiving ECU reads the data from the CAN_H and CAN_L potential difference. "Recessive" refers to the state where both CAN_H and CAN_L are under the 2.5-V state, and "Dominant" refers to the state where CAN_H is under the 3.5-V state and CAN_L is under the 1.5-V state. By transformation mainly to 2.5V, even in cases when voltage is rendered 0 from faulty grounding or the like (causing a problem of an approximate 0.5 voltage increase on the communications line), communication can be continued uninterrupted. Employing dual communications lines improves reliability to prevent the presence of noise, compared to the conventional communication method.

DATA FRAMES



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SOF (Start of Frame)

- Indicates the start of the frame

ID (Identifier) region

- Identifies the data content while specifying priority rank in case of mediation

Control region

- Specifies the frame type, data length, etc.

Data region

- Values used for data control, etc.

Cyclic Redundancy Check (CRC) region

- Region where to check for errors in sent data The transmitting ECU calculates data regions by applying prescribed operations and stores the results. The receiving ECU detects erroneous communication by comparing the CRC region with the data region.

ACK (Acknowledge) region

- Region where to conform the reception of sent data

EOF(End of Frame)

- Indicates the end of the frame

ERROR DETECTION AND RECOVERY

CAN protocol secures its reliability of communication by providing several error detection function such as CRC shown in data frame, and the recovery function (recovery is performed by resending, from abnormal state such as transmission errors). If an error is detected but it is not resolved even after recovery, communication is stopped. This state is called "Bus Off."

SELF-DIAGNOSIS

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- CAN self-diagnosis is performed by each ECU connected to the CAN bus.
- Diagnostic trouble codes related to communication are named with the capital letter U, and are called "U-codes."
- A summary of the CAN self-diagnosis system is presented below. For further details on each diagnosis code stored by the ECUs, consult the U-Code Diagnostic Trouble Code List P.54C-8.

TIMEOUT

Each ECU transmits data frames periodically. If the intended receiving ECU cannot receive the data frame within the specified period, it sets a diagnosis code indicating communication timeout for the ECU that failed to transmit. A data length is assigned to each data frame. If a data length is shorter or longer than the specified, the ECU cannot receive the data.

BUS OFF

Related to a communication error that persists even after the transmitting ECU attempts recovery for a specified number of attempts or that persists for a specified period after recovery. Communication is stopped and this diagnostic code is issued.

FAILURE DATA

When the transmitting ECU detects failure of a sensor directly connected to it, this is the pertinent data used to inform the ECU.

DYNAMIC RANGE ERROR

When the data received exceeds or is less than the prescribed range, this diagnosis code is issued.

CAN BUS DIAGNOSTICS

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As ECUs are connected via CAN bus (including MUT-III), always diagnose CAN bus to confirm its normality when inspecting. Simply by performing MUT-III screen operations, the following inspections can be performed automatically, and the result can be used to verify the CAN bus status.

- Voltage measurement between the CAN_L and CAN_H and the body grounding terminal
- Resistance measurement between the CAN_L and CAN_H
- Confirmation of communication of all ECUs

CAN COMMUNICATION SIGNAL TABLE

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- Aa: ABS-ECU <Vehicles without active stability control system>
- Ab: ABS/Active stability control system-ECU <Vehicles with active stability control system>
- B: G and yaw rate sensor <Vehicles with active stability control system>
- C: Steering wheel sensor <Vehicles with active stability control system>
- D: Engine-ECU <M/T> or Engine-transmission-ECU <Automated manual transmission>
- E: Combination meter
- F: A/C-ECU
- G: Electric power steering-ECU
- H: Centre display unit
- I: ETACS-ECU
- J: SRS-ECU

SIGNAL	TRANS MITTER ECU	RECEIVER ECU										
		Aa	Ab	B	C	D	E	F	G	H	I	J
Parking brake signal	Aa or Ab	–	–	–	–	●	●	–	–	–	–	–
ABS indicator warning lamp request signal		–	–	–	–	–	●	–	–	–	–	–
Active stability control information lamp request signal		–	–	–	–	–	●	–	–	–	–	–
EBD fault or brake fluid level too low signal		–	–	–	–	–	●	–	–	–	–	–
Brake light switch signal		–	–	–	–	●	–	–	–	–	–	–
Brake switch signal		–	–	–	–	●	–	–	–	–	–	–
Front wheel speed signal		–	–	–	–	●	●	–	●	–	–	–
Rear wheel speed signal		–	–	–	–	●	●	–	–	●	–	–
Rear left side wheel speed signal for cruise control		–	–	–	–	●	–	–	–	–	–	–
Target gear request signal		–	–	–	–	●	–	–	–	–	–	–
System signal		–	–	–	–	●	–	–	–	–	–	–
Active stability control system brake action signal		–	–	–	–	●	–	–	–	–	–	–
Brake torque adjust signal		–	–	–	–	●	–	–	–	–	–	–
Brake pedal condition signal		–	–	–	–	●	–	–	–	–	–	–
Clutch condition signal <Active stability control system>		–	–	–	–	●	–	–	–	–	–	–
Engine torque request signal		–	–	–	–	●	–	–	–	–	–	–
Vehicle transversal acceleration at gravity centre		–	–	–	–	●	–	–	–	–	–	–
Yaw rate signal	B	–	●	–	–	–	–	–	–	–	–	–
Lateral gravity signal		–	●	–	–	–	–	–	–	–	–	–
Steering wheel angle signal	C	–	●	–	–	–	–	–	–	–	–	–
Steering wheel angle rotation speed signal		–	●	–	–	–	–	–	–	–	–	–

SIGNAL	TRANSMITTER ECU	RECEIVER ECU										
		Aa	Ab	B	C	D	E	F	G	H	I	J
Immobilizer signal	D	–	–	–	–	–	–	–	–	–	●	–
A/C information signal		–	–	–	–	–	–	●	–	–	–	–
Engine condition signal		–	–	–	–	–	–	–	–	–	●	–
Engine torque signal		–	●	–	–	–	–	–	–	–	–	–
Engine warning buzzer request signal		–	–	–	–	–	–	–	–	–	●	–
Accelerator pedal condition signal		–	●	–	–	–	–	–	–	–	–	–
Clutch switch signal <M/T>		–	●	–	–	–	–	–	–	–	–	–
Clutch condition signal		–	●	–	–	–	–	–	–	–	–	–
Engine speed signal		–	●	–	–	●	●	–	●	–	–	–
Malfunction indicator lamp request signal		–	–	–	–	–	●	–	–	–	–	–
Engine coolant temperature signal		–	–	–	–	–	●	–	–	–	–	–
Fuel consumption signal		–	–	–	–	–	–	–	–	●	–	–
Fan relay control signal		–	–	–	–	–	–	–	–	–	●	–
Selector position signal <Automated manual transmission>		–	●	–	–	–	●	–	–	–	●	–
Kick down signal		–	●	–	–	–	–	–	–	–	–	–
Lost torque signal		–	●	–	–	–	–	–	–	–	–	–
Fuel information signal	E	–	–	–	–	●	–	–	–	●	–	–
Vehicle speed signal		–	–	–	–	●	–	–	–	–	–	–
Environment temperature signal		–	–	–	–	●	–	●	–	●	●	–
Odometer signal		–	–	–	–	●	–	–	–	–	●	–
Communication continuation request signal		–	–	–	–	–	–	–	–	–	●	–
Seat belt buzzer request signal		–	–	–	–	–	–	–	–	–	●	–
Air conditioner switch signal	F	–	–	–	–	●	–	–	–	–	–	–
Increacing idle speed signal		–	–	–	–	●	–	–	–	–	–	–
Cooling fan request signal		–	–	–	–	●	–	–	–	–	–	–
Air conditioner refrigerant pressure signal		–	–	–	–	●	–	–	–	–	–	–
Air conditioner compressor drive duty signal		–	–	–	–	●	–	–	–	–	–	–
Motor current signal	G	–	–	–	–	●	–	–	–	–	–	–
Electric power steering fail lamp signal		–	–	–	–	●	●	–	–	–	–	–

SIGNAL	TRANS MITTER ECU	RECEIVER ECU										
		Aa	Ab	B	C	D	E	F	G	H	I	J
Buzzer sound signal	H	–	–	–	–	–	–	–	–	–	●	–
Ignition switch (ACC) signal		–	–	–	–	–	–	–	–	–	●	–
Communication continuation request signal		–	–	–	–	–	–	–	–	–	●	–
Immobilizer signal	I	–	–	–	–	●	–	–	–	–	–	–
Ignition switch (IG1) signal		–	–	–	–	–	●	–	–	–	–	–
Illumination signal		–	–	–	–	●	●	–	–	●	–	–
Fog light indicator request signal		–	–	–	–	–	●	–	–	–	–	–
Column switch condition signal		–	–	–	–	–	●	–	–	–	–	–
Door switch condition signal		–	–	–	–	●	●	–	–	–	–	–
Instruction to enter CAN sleep mode signal		–	–	–	–	–	●	–	–	–	–	–
ETACS plausibility signal		–	–	–	–	●	–	–	–	–	–	–
Daytime running lights condition signal		–	–	–	–	●	–	–	–	–	–	–
SRS warning lamp illumination request signal	J	–	–	–	–	–	●	–	–	–	–	–
Door unlock request signal		–	–	–	–	●	–	–	–	–	–	–
Engine stop request signal		–	–	–	–	●	–	–	–	–	–	–

CAN COMMUNICATION-RELATED DIAGNOSIS CODE (U CODE) TABLE

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OUTPUT ECU	CODE NO.	DIAGNOSTIC ITEM	ACTION
Engine-ECU <M/T> or Engine-A-M/T-ECU <Automated manual transmission>	U1073	Bus Off	CAN main bus line diagnostics
	U1102	ABS or ASC/Active stability control system-ECU time-out	
	U1106	Electric power steering-ECU	
	U1108	Combination meter time-out	
	U1109	ETACS-ECU time-out	
	U1110	A/C-ECU time-out	
	U1112	SRS-ECU time-out	
ABS-ECU	U1073	Bus Off	CAN main bus line diagnostics

OUTPUT ECU	CODE NO.	DIAGNOSTIC ITEM	ACTION
ABS/Active stability control system-ECU	U1073	Bus Off	CAN main bus line diagnostics
	U1100	Engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> time-out (related to engine)	
	U1101	Engine-A-M/T-ECU time-out (related to automated manual transmission)	
	U1104	Steering wheel sensor time-out	
	U1105	G and yaw rate sensor time-out	
	U1108	Combination meter time-out	
	U1109	ETACS-ECU time-out	
	U1406	Failure information on engine-A-M/T-ECU (related to engine)	Diagnose CAN main bus lines and confirm input signals.
	U1413	Failure information on engine-A-M/T-ECU (related to automated manual transmission)	
	U1426	Failure information on engine-A-M/T-ECU (related to engine)	
	U1427	Failure information on engine-A-M/T-ECU (related to engine)	
	U1428	Failure information on engine-A-M/T-ECU (related to engine)	
	U1429	Failure information on engine-A-M/T-ECU (related to engine)	
	U1430	Failure information on engine-A-M/T-ECU (related to engine)	
	U1431	Failure information on engine-A-M/T-ECU (related to automated manual transmission)	
Steering wheel sensor	U1073	Bus Off	CAN main bus line diagnostics
Combination meter	U1073	Bus Off	CAN main bus line diagnostics
	U1100	Engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> time-out (related to engine)	
	U1101	Engine-A-M/T-ECU time-out (related to automated manual transmission)	
	U1102	ABS or ASC/Active stability control system-ECU time-out	
	U1109	ETACS-ECU time-out	
	U1120	Failure information on engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> (related to engine)	Diagnose CAN main bus lines and confirm input signals.

OUTPUT ECU	CODE NO.	DIAGNOSTIC ITEM	ACTION
Multi-centre display unit (middle-grade type)	U1073	Bus Off	CAN main bus line diagnostics
	U1100	Engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> time-out (related to engine)	
	U1101	Engine-A-M/T-ECU time-out (related to automated manual transmission)	
	U1108	Combination meter time-out	
	U1109	ETACS-ECU time-out	
	U1110	A/C-ECU time-out	
	U1120	Failure information on engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> (related to engine)	Diagnose CAN main bus lines and confirm input signals.
	U1128	Failure information on combination meter	
	U1130	Failure information on A/C-ECU	
ETACS-ECU	U1073	Bus Off	CAN main bus line diagnostics
	U1100	Engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> time-out (related to engine)	
	U1101	Engine-A-M/T-ECU time-out (related to automated manual transmission)	
	U1102	ABS or ASC/Active stability control system-ECU time-out	
	U1108	Combination meter time-out	
	U1111	Multi-centre display unit (middle-grade type) time-out	
	U1112	SRS-ECU time-out	
	U1121	Failure information on engine-A-M/T-ECU (related to automated manual transmission)	Diagnose CAN main bus lines and confirm input signals.
	U1128	Failure information on combination meter	
A/C-ECU	U1073	Bus Off	CAN main bus line diagnostics
	U1100	Powertrain control module time-out (related to engine)	
	U1108	Combination meter time-out	
	U1109	ETACS-ECU time-out	

OUTPUT ECU	CODE NO.	DIAGNOSTIC ITEM	ACTION
Electric power steering-ECU	U1073	Bus Off	CAN main bus line diagnostics
	U1100	Engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> time-out (related to engine)	
	U1102	ABS or ASC/Active stability control system-ECU time-out	
	U1120	Failure information on engine-ECU <M/T> or engine-A-M/T-ECU <Automated manual transmission> (related to engine)	
	U1122	Failure information on ABS or active stability control system-ECU	Diagnose CAN main bus lines and confirm input signals.